

**Grant Application
For a CO₂ Capture
Demonstration Project**

Presented to:

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ABSTRACT

The Antelope Valley Station (AVS) carbon capture project will demonstrate the removal of carbon dioxide from the flue gas of a lignite-fired boiler. The project is designed to capture carbon dioxide (CO₂) on a 120 MW slipstream from the AVS Unit 1. The system works by first removing sulfur dioxide (SO₂) using Powerspan's ECO-SO₂ technology, and then absorbing CO₂ using Powerspan's ECO₂ technology. The combined system employs two absorber towers with an ammonia based chemical process. The net result of the process is 90 percent removal of CO₂ from the treated flue gas, 3000 short tons per day of pipeline quality CO₂, and a liquid stream of ammonium sulfate for use in making fertilizer crystals. A diagram of the AVS carbon capture project is shown in Appendix B.

The feasibility study concluded that the operational impact of the new Process Island at AVS was relatively minimal compared to other CO₂ capture technologies. Space and all utility service requirements (power, steam, cooling water, and process water) are available for the new systems. Impacts between the Great Plains Synfuels Plant and AVS are limited as there are relatively simple connections (pipelines) between the facilities. After careful consideration of the engineering issues raised from integration of the new and old system, no apparent fatal flaws for the project were identified.

A Front End Engineering and Design (FEED) study is the next step for this project. The FEED study is expected to take six months. The FEED scope is sufficiently detailed to provide Basin Electric with the necessary information (engineering detail, schedule, and cost estimate +/- 15 percent) to evaluate the economic viability of the project. The cost for the FEED study is expected to be \$5.0 million. At the conclusion of the FEED phase, Basin Electric will decide whether to move forward on the project and commit the necessary resources to begin procurement, continue design engineering, and start contracting for construction.

PROJECT SUMMARY

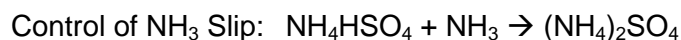
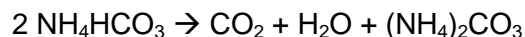
The Antelope Valley Station CO₂ capture demonstration project consists of the capture and compression of 3,000 tons per day of CO₂ gas that is currently emitted from the Unit 1 stack. To capture this CO₂, a slip stream of about one-fourth of the Unit 1 flue gas (the equivalent of about 120 MW) will be rerouted through the Powerspan equipment. First, the flue gas taken from the downstream side of the induced draft fans will pass through a new booster fan to increase the pressure to overcome the resistance of moving it through the new equipment. Then the flue gas passes through the first vessel and makes countercurrent contact with an aqueous ammonia solution which reacts with the remaining SO₂ (approximately 170 parts per million (ppm)) to create ammonium sulfate. This ammonium sulfate solution is then purged from the vessel and pumped to Great Plains Synfuels Plant to be incorporated into the existing ammonium sulfate processing area.

The flue gas which now has less than one ppm of SO₂ remaining, continues through the Powerspan process and is cooled by a flue gas heat exchanger. From there, the flue gas enters the CO₂ absorber vessel. Again, the flue gas makes countercurrent contact with an aqueous ammonia solution where the CO₂ bonds to the aqueous ammonia forming ammonium carbonate and ammonium bicarbonate. The treated flue gas, now 90 percent free of CO₂, can either be brought back to the existing stack or vented from the top of the absorber vessel depending on air dispersion modeling results and environmental requirements. The chemistry of the ECO₂ absorption process is as follows: $\text{CO}_2 + \text{H}_2\text{O} + (\text{NH}_4)_2\text{CO}_3 \rightarrow 2 \text{NH}_4\text{HCO}_3$

The CO₂ that is entrained in the solution then gets pumped to the regenerator vessel. Within the regenerator vessel, a proprietary process removes the CO₂ from solution and further purifies it to pipeline quality. The CO₂ gas is then compressed to pipeline pressure while the solution is

brought back to the absorber vessel to capture more CO₂. The CO₂ will be injected into the existing Great Plains Synfuels Plant's pipeline.

The chemistry of the ECO₂ regeneration process is as follows:



The Powerspan process and facility requires steam, cooling water, fire protection water, potable water, ammonia, and electrical power. The steam requirement will likely be fulfilled by an additional steam extraction from the existing AVS Unit 1 steam turbine. The cooling requirement is assumed to be served with evaporative cooling, but more study is needed to confirm that this is the best method. The fire protection and potable water streams along with the storm and sanitary sewer systems are expected to be extensions of the existing plant systems. The electrical power needs will also be an extension of the existing plant systems since they will be served with an expansion of the existing auxiliary power system.

Other than treated flue gas, the outputs from the Powerspan process are CO₂ and ammonium sulfate. Both of these will be brought across the fence to Great Plains Synfuels Plant via pipeline. The ammonium sulfate will go through processing to produce fertilizer crystals and the CO₂ will go through final compression and be introduced into the pipeline where it can be transported to oil companies to be used in enhanced oil recovery.

Feasibility Study Overview

Powerspan conducted an extensive 3-month study for Basin Electric Power Cooperative (Basin Electric) to determine the feasibility of installing Powerspan's ECO₂ technology at AVS and integrating it with the Great Plains Synfuels Plant. Powerspan led an experienced team of

engineering firms to support the effort. The firms gathered data on site at AVS, collected and reviewed existing drawings, provided independent analysis of utility needs and interconnections, and provided estimates of capital costs for construction.

The primary objectives of the Feasibility and Conceptual Engineering Study (Feasibility Study) were to:

- Determine the impact Powerspan's ECO₂ system will have on existing plant operations, Identify any potential fatal flaws associated with the CO₂ capture technology and/or fatal flaws associated with incorporating the technology into the Antelope Valley Station;
- Provide a +/- 30% cost estimate for delivery of a 120 MW ECO₂ system;
- Estimate the cost of a Front End Engineering and Design (FEED) Study to achieve a +/- 15% cost estimate for delivery of a 120 MW ECO₂ system.

The study was conducted between March and May 2008 and concluded with a detailed engineering report containing engineering drawings, layouts, evaluations, equipment lists, estimates, and plans for future work. Over 3,200 engineering hours were invested on the project. The report was reviewed by all parties and was sufficiently detailed to assure the team that the ECO₂ technology was a viable project for AVS. The following summary covers the key conclusions from the full report.

Impacts on Plant Operations

The ECO₂ project will impact existing operations at AVS and Great Plains Synfuels Plant. These impacts were extensively investigated and wherever possible assigned a cost in the capital and operations and maintenance estimates. Total impacts of the project are estimated at 28 MW including electrical power consumption, steam extraction, and lost electricity

generation. At AVS, impacts are predicted to be a capacity loss of 18.74 MW (10.74 MW for process electrical loads and 8 MW in lost generation due to steam extraction). At the Great Plains Synfuels Plant, final compression to pipeline pressure will require 9.26 MW.

In addition, there are operational impacts such as space requirements for buildings, water consumption for process equipment, road layout changes, and additional maintenance requirements. Operational impacts were determined to be manageable, and effects on the existing plant were mitigated by design decisions and a simple strategy for isolating the slipstream from the main flue gas ducts.

Fatal Flaw Analysis

Fatal flaws were an important area of inquiry in the report. Basin Electric was very interested in ensuring there were no conditions that would preclude incorporation of ECO₂ technology at AVS. Key areas that were investigated included: steam extraction from the Unit 1 turbine, provision of sufficient auxiliary electrical power, cooling water demand, treated make-up water demand, physical layout, and impacts on power generation.

The engineering firm assigned to the fatal flaw analysis looked at all potential flaws, with an emphasis on the above list. In addition, the Basin Electric project team challenged design assumptions and used their extensive plant knowledge to point out areas of concern. After careful consideration, the team determined all engineering hurdles had a practical engineering solution that could be implemented at AVS. However, more study is required to better understand the effects on the steam turbine with the increased extraction steam flow to the process and also the effects of the treated flue gas slip stream combining with the other flue gas to exit through the existing stack.

Estimates

Detailed Capital and Operations & Maintenance (O&M) cost estimates were provided to Basin Electric. Capital costs were established by defining a conceptual design for the balance of plant and the Process Island. The engineering firms were assigned specific areas to estimate. In preparing their estimates, estimators gathered direct quotes from vendors, used extensive historical information from previous projects, performed takeoffs and quantity calculations for equipment, and applied current materials pricing to arrive at a +/- 30% estimate in 2008 dollars. The project is expected to cost between \$200 million and \$300 million in 2008 dollars.

The all inclusive estimated cost per ton of pipeline ready CO₂ is expected to be \$45-50 per ton in 2012. O&M costs were determined by using actual operating loads of existing equipment, calculated loads for expected operating conditions for new equipment, a manning model using local labor costs, and actual costs for chemicals supplied by GPSP to AVS. In addition, the value of SO₂ credits and ammonium sulfate produced were included to establish economics for the business model.

Front End Engineering and Design (FEED)

A FEED plan was prepared to identify work required to move the project forward. The FEED scope was detailed through a collaborative effort between Basin Electric and the engineering firms to be involved in the FEED effort. After an extensive scoping review, the critical activities for advancing the engineering design were established. These FEED activities would allow the project team to establish an overall project schedule and a detailed cost estimate with an accuracy of +/- 15%, which would allow Basin to make a decision about committing the resources necessary to install the ECO₂ technology. Permitting by Basin Electric will need to commence early in the FEED phase and will extend into the detailed engineering phase.

Project Schedule

The complete project is expected to take 42 months: six months for FEED phase and 36 months for detailed engineering, procurement, and construction. The FEED work commences first and will generate a more detailed design and a + / - 15% cost estimate for the total project. This work will fully define the scope in order for the detailed design work to begin. After the FEED phase, the 36-month engineering, procurement, and construction will begin.

The major commitment to the project will occur after the FEED phase. At this time, Basin Electric will be committing the necessary resources to continue engineering, begin procurement and for final detailed design work. Lead times for delivery established during the FEED and construction sequencing will allow completion of the full project schedule. Critical items for the schedule are permitting, long lead time equipment procurement, early start of the air dispersion modeling study at the beginning of the FEED phase, and short decision/negotiation periods between phases.

PROJECT DESCRIPTION

AVS CO₂ Front End Engineering Design (FEED) Study Scope

The objective of the FEED study is to provide Basin Electric and Powerspan with enough information to make a decision on the final project notice to proceed. At the end of the FEED study, the project scope and execution plan should be frozen. After a final notice to proceed, detailed engineering and procurement of long lead-time items will begin, as they may be the project critical paths.

In general, the FEED study requires sufficient engineering, design, and cost estimation to arrive at a total project cost estimate accuracy of +/-15%. Optimization and further design will take place to gain further knowledge and definition of the proposed project and its requirements.

The scope of work will include all supporting balance of plant equipment needed to capture and compress the CO₂ per the previous feasibility study. The feasibility study will act as a basis for the FEED study; however, optimization and further design will take place to gain further knowledge and definition of the proposed project and its requirements.

Throughout the feasibility study, several assumptions were made due to limited time and scope constraints. The feasibility study showed a conceptual layout of how the CO₂ capture process might work at the Antelope Valley Station. In the FEED study, these assumptions will be thoroughly studied to understand the optimum way to support Powerspan's ECO₂ capture process and seamlessly integrate it into the existing Antelope Valley Station and Great Plains Synfuels Plant processes.

The FEED optimization studies for plant integration include evaluating the best way to take the flue gas slipstream from the existing system and how best to either put it back into the existing stack or just release it from a new stack. There are several challenges to work through including a new way to measure, calculate, and report emissions to the Environmental Protection Agency since some emission measurements are dependent on the amount of CO₂ in the flue gas.

Another optimization study is to determine the best way to serve the cooling requirements of the Powerspan process. The optimal type and source of cooling is yet to be determined. Furthermore, the cooling could stand alone or be integrated into the existing system.

The Powerspan process with its associated buildings will require several other supporting resources which will be studied and optimized throughout the FEED phase. These include but are not limited to process water, potable water, sanitary and storm sewer, and fire protection water.

The FEED study will determine the optimization and arrangement of the supporting plant equipment and resources. The design work will proceed after this determination. The balance of plant systems and Powerspan's ECO-SO₂ and ECO₂ systems will follow a similar approach in design. First, the process flow diagrams created in the feasibility study will be reviewed and finalized. Next, the general arrangement drawings from the feasibility study will be modified with additional detail. The mass and energy balance will be finalized from the process flow diagrams. This will define the utility requirements that will be needed for the ECO-SO₂ and ECO₂ processes.

The FEED study will provide piping and instrumentation diagrams to show how the process needs will be met. An equipment list will be created to identify all of the major equipment needed. From this list, long lead items are identified to determine the critical path of the project schedule. After the piping and instrumentation diagrams and electrical load lists are completed; the instrument and controls input/output list can be determined. The next step is to produce the electrical one-line diagrams. Finally, the major equipment and piping will be shown on a preliminary 3-D CADD model to identify any possible interference problems.

The project cost estimates can be completed after the preliminary design and the project scope is well defined. The FEED will ascertain both the capital cost and operating and maintenance costs within +/- 15% accuracy. The final step will sharpen the project schedule to incorporate Powerspan's ECO₂ capture process at the Antelope Valley Station.

To further define the scope of the FEED study, below are some general descriptions of the expected deliverables and also clarification to selected line items in the "AVS FEED Schedule."

FD1004 Contract Negotiations and Award

During this time, Basin Electric will discuss the contractual approach and financial model of the project with Powerspan. Upon successful negotiations, Basin Electric may request that the Basin Electric Board of Directors award a contract for the FEED study. The deliverable will be a contract between Powerspan and Basin Electric and will include:

FD1030 Review Permitting Assistance Requirements

Basin Electric would lead the efforts to gain approval from the appropriate regulatory agencies for this project. Any assistance needed should be identified in this phase.

The deliverable will be Permit applications and/or the actual permits.

FD1061 Develop/Issue - Scope, Execution plan

The scope of work will include all supporting balance of plant equipment needed to capture and compress the CO₂ per the previous feasibility study. The execution plan will be developed from this document.

FD1100 Develop/Issue ECO-SO₂, ECO₂ and BOP Systems Requirements/Design Basis

Powerspan is to issue an updated Design Basis incorporating new data from Plant Studies.

The deliverable will include:

- Mass Balance
- Operating Design maximum and minimum loads for major components
- Equipment lists (Equipment Lists - The major equipment lists must be 100 percent defined and will include all vessels, pumps, fans, compressors and any other necessary equipment. Equipment lists will be broken out by project segment: balance of plant (BOP); Process Island (PI); Interconnecting Piping (ICP); Electrical & Controls.
- Long lead items will be specifically called out in the equipment list
- Electrical load list
- Spare parts list
- Equipment, insulation, and specialty coating specifications
- Piping material, insulation, and specialty coating specifications

- Piping service index utility requirements - The utility requirements for the process will be 100 percent defined from the completion of the mass and energy balance.

FD1115, 1315, 1865 - Develop/Issue Process Flow Diagrams (PFD)

The process flow diagrams will be 100 percent complete at the completion of the FEED study.

The deliverable will be a full set of PFDs.

FD1155 Basin to Evaluate and Determine Method of Project Delivery

The deliverable will be a letter from Basin Electric stating method of project delivery. This letter will identify the Owner's Architect/Engineer if this is the preferred method of executing the project.

FD1158 Basin to Select Construction Management

The deliverable will be a letter from Basin Electric describing Construction Management type and/or naming a construction management firm.

FD1160 Perform/Issue Labor Study

The deliverable will be the write up of the study including any relevant data.

FD1190, 1390, 1960, 1970, 1985, 2000, 2015 Develop/Issue Piping and Instrumentation Diagrams (P&ID)

The piping and instrumentation diagrams should be preliminary for the balance of plant (BOP), Process Island (PI), and Interconnecting Piping (ICP), including all major process piping.

However, there will be small bore process pipes and service piping that will not be included in

the piping and instrumentation diagrams (P&IDs) developed such as plumbing within the building. The piping, equipment and materials not included in the deliverable piping and instrumentation diagrams must be included in the cost estimates developed.

The deliverable will be a full set of piping and instrumentation diagrams.

FD1200, 1400, 2090 Perform/Issue One Line Drawings

One-line drawing for all new equipment and related items will be completed.

The deliverable will be a complete set of one-line drawings.

FD1201 Develop/Issue Preliminary 3-D CADD Model for ECO SO₂, ECO₂ & BOP Systems

The preliminary 3-D CADD should include all major equipment and recycle piping. The preliminary 3-D CADD should include all major equipment and pipe routings including but not limited to:

- Process Island
- Balance of plant
- Interconnecting piping
- The general arrangement
- Pipe routing from AVS to Great Plains Synfuels Plant
- Steam piping and condensate return from AVS
- Cooling water piping
- Makeup water piping
- Flue gas duct work
- Electrical power routing
- Fire protection water to the Powerspan Process Island

- Storm sewer from the Powerspan building
- Sanitary sewer from the Powerspan building
- Potable water to the Powerspan building
- 3-D models to be constructed such that they will mate with all other 3-D models for this project. A final model comprised of each section model will be assembled.

The deliverable will be the 3-D CADD model. All final engineering drawings shall be provided to the Owner in AutoCAD “.dwg” format. Electronic formatting other than AutoCAD will require approval from the Owner. Upon review of format, Owner will accept Microsoft Visio files and Microstation Version 8 files. Microstation Version 8 documents must use cells created with tags only, not data fields.

FD1401 Develop/Issue – Design Specifications

The deliverable will be discrete bid level specifications for major equipment. Major equipment will be defined in the equipment list.

FD1700 Perform/Issue Stack Study

The stack study will assume that the “treated” flue gas stream, which is 90 percent CO₂ free and cooler than the other flue gas, will come from the Powerspan process and be brought back into the existing flue gas stream between the existing induced draft (ID) fans and stack. The stack study will investigate two major areas; the cooler flue gas stream and the Continuous Emissions Monitoring System (CEMS). Computational Fluid Dynamics (CFD) should be used where required.

The injection of cooler flue gas into the existing flue gas stream must be studied to understand:

- The mixed flue gas temperature after the cooler flue gas is injected
- Condensation effects due to the cooler flue gas
- Proper design to promote adequate mixing in the duct work
- Effects on the duct work and stack materials due to the cooler flue gas

The CEMS design must be studied to understand the best way to measure these pollutants under all operating scenarios with the Powerspan process in place. Measurement includes:

- SO₂ (lb/hr)
- NO_x, (lb/MMBTU)
- Heat Input (MMBTU/hr)
- CO₂ (Tons/hr)
- Particulate

If stack stratification is present due to the injection of a cooler flue gas stream and thorough mixing is not possible, then a design will be formulated to overcome the stratification and accurately collect the CEMS data.

The deliverable will be the write up of the study including any relevant data.

FD1705 Perform/Issue Duct Take-off Study

The feasibility duct take-off study (taking and returning the slip stream) should verify that the proposed locations for penetrating the existing flue gas duct work are in the optimum location.

This study should also identify the best materials to be used in these take-off locations. Careful

consideration should be given to design flue gas mixing of the treated flue gas stream and the larger untreated stream. (See tie-in details FD1724 for connections to and from existing ductwork.)

Perform/Issue Gas Flow Modeling-Computational Fluid Dynamics (CFD) modeling will be performed to evaluate the existing flue gas plenum, new inlet flue, booster fan and outlet flue for the ECO₂ technology. Also the CFD study will determine how this equipment affects the gas as it passes through the system and eventually exits the existing stack. The study will address gas distribution, the need for enhanced mixing of the gasses, temperature distribution and recommended materials of construction. The results may indicate that a physical model is appropriate; however, we do not expect physical modeling to occur until procurement of the major project components after the FEED is completed.

The deliverable will be the write up of the study including any relevant data.

FD1710 Perform/Issue Steam Extraction/Turbine Impact Study

Further study is needed to verify that the feasibility study identified the optimum place to provide steam to the Powerspan process and return condensate to the power plant system. When the optimum interfaces are determined, a mechanical stress analysis is needed if the optimum steam source is a turbine extraction.

An optimization study of the steam source and how the condensate return interfaces with the power plant will be conducted. When the optimization is complete, the deliverable will include turbine heat balances with the Powerspan steam extraction and condensate return through the various possible range of power plant operation with the Powerspan process. This will determine the effects on the AVS power plant system.

If the optimum source for steam is a steam turbine extraction point, a mechanical stress analysis is needed to determine the effects of the extraction on the mechanical strength of the steam turbine. The effects may show that the steam turbine can handle the new extraction or it may show that the new steam extraction may cause a mechanical failure of the existing steam turbine. If so, recommendations should be given to remedy this outcome.

Also to be investigated is an alternative steam source for ECO₂ with capability to be a redundant source and/or to be used during reduced load operation of AVS. A determination of the steam turbine heat balance tuning to reflect actual operating conditions rather than original design conditions will be made.

An evaluation of the impacts of a new steam path redesign, upgrade, and replacement options will be conducted. In addition, the lost generation from the extraction will be quantified.

The deliverable will be the write up of the study including any relevant data.

FD1715 Perform/Issue Fan Study

The flue gas slip stream take-off and return for the Powerspan process are both located between the existing ID fans and stack. The study will verify that the Powerspan process will not cause the power plant process to be curtailed or trip off-line under any combination of operating scenarios between the power plant and the Powerspan process. If possibilities of impact to the power plant are found, options to incorporate controls or other design to prevent such an adverse impact to the power plant will be recommended.

Booster Fan Operations and Efficiency Study: The parasitic load of the booster fan may be reduced by evaluating the life cycle cost of applying variable frequency drives or use of axial flow fans to minimize lost capacity, including the effects of fan design margin.

The deliverable will be the write up of the study including any relevant data.

FD1720 Perform/Issue Redundancy Study

A redundancy plan should be completed to identify the equipment with and without redundancy. The equipment with redundancy will be specified to explain the details of each redundancy. Finally, the plan should explain the overall expected availability with the proposed redundancy in place.

Redundancy and reliability should be studied to determine where redundancy is appropriate based on risk and cost.

The deliverable will be the write up of the study including any relevant data.

FD1724 Perform/Issue Tie-in study

The tie-in study will identify all tie-in points for all piping/duct work connections with existing piping/ductwork. The tie-in drawings will indicate the exact point of tie-in and will be denoted on the piping and instrumentation diagrams as well as on the proper isometric piping drawing. The tie-in will be identified as to whether or not the piping will be cut and welded or if the tie-in will use existing unoccupied flanges or connections. This will require a plant visit and the help of

plant personnel. Existing unoccupied “tees” etc., should be used to minimize cutting and welding where possible. Existing plant piping and instrumentation diagrams will be used to identify generally where to tie-in.

The deliverable will be the write up of the study including any relevant data.

FD1725 Perform/Issue Reliability Study

A statistical reliability analysis will be conducted for critical systems on this project. The deliverable will be a list of equipment with a reliability number assigned to its appropriate piece of equipment.

The deliverable will be the write up of the study including any relevant data.

FD1730 Perform/Issue Electric Power Distribution Study

This study will determine the optimum source of electrical power to provide the Powerspan process equipment and the CO₂ compressor with the necessary electrical power needs. This source of electrical power will then be designed with the existing power plant auxiliary power redundancy design. Basin Electric may also request that the power distribution be sized for a larger capacity than needed for the Powerspan process to accommodate any future equipment that needs auxiliary power. The design will include a design of 125 volt DC system to aid in plant shut down.

Perform/Issue Short Circuit Analysis - An analysis will be performed to assure that existing equipment capacity is not exceeded and mitigation measures identified, including equipment replacement if necessary.

The deliverable will be the write up of the study including any relevant data.

FD1740 Perform/Issue Compression Optimization Study

The feasibility study assumed that the CO₂ compressor would be located at the Great Plains Synfuels Plant existing CO₂ compression building. This study will determine the optimal location for the new CO₂ compressor. Consideration will be given to a site near the capture equipment at Antelope Valley Station (AVS) and also at the previously assumed existing compression site at DGC. Finally, this study should verify whether the current type of compressor is the best for the project or an alternative compressor technology should be considered.

The deliverable will be the write up of the study including any relevant data.

FD1742 - Perform/Issue Optimum Ammonium Sulfate Study

Further study is needed to identify the optimum ammonium sulfate stream to use from the Great Plains Synfuels Plant. This effort will include review of the composition of all available streams from the flue gas desulphurization unit and will determine which stream is most desirable for use in ECO-SO₂ and ECO₂ process.

The deliverable will be verification by Powerspan, Basin Electric, & the Great Plains Synfuels Plant that the take off point for ammonium sulfate will be the correct point for both location and chemistry.

FD1745 Perform/Issue Material Flow & Transportation Adequacy Study

This study will verify that the road layout is adequate to give proper access for maintenance and day-to-day operations traffic. The study will also detail the material flow between the Great Plains Synfuels Plant and AVS to design for continuous operation through upsets in supply from either AVS or DGC regarding:

- Aqueous Ammonia from the Great Plains Synfuels Plant
- Ammonium Sulfate from the Great Plains Synfuels Plant
- Ammonium Sulfate from AVS
- CO₂ from AVS
- Tanks for temporary fluid storage

During an upset of delivery, recommendations will be given to continue operation of the Powerspan process by having a supply in appropriately sized storage tanks at AVS and/or deliveries of the aqueous ammonia and ammonium sulfate by truck. If operation cannot continue with an upset in delivery, such as CO₂, then these vulnerabilities will be identified.

This study will determine the optimum way to route the piping between the Great Plains Synfuels Plant and AVS by confirming a route and establishing the cost differences between above and below grade installations.

The deliverable will be the write up of the study including any relevant data.

FD1750 Perform/Issue Balance of Plant (BOP) Water Balance Study

The feasibility study assumed that AVS would provide water to the Powerspan process (cooling tower makeup) and that any output of water from the Powerspan process would be in the

ammonium sulfate stream that is sent to DGC. The water balance study will identify the best source to supply water to the Powerspan process and the best place to discard any liquid generated by the Powerspan process.

The deliverable will be the write up of the study including any relevant data.

FD1760 Perform/Issue Fire Protection Study

The fire protection study will determine if there is adequate capacity in the existing fire protection system at AVS to add the duty needed for the new Powerspan process building. If not, this study will identify how the fire protection needs of the Powerspan process will be met.

The deliverable will be the write up of the study including any relevant data.

FD1775 Perform/Issue Transient Control & Boiler Implosion Study

This study will identify any increased risk of boiler implosion with the Powerspan process integrated in the current system. If an increased risk is found, the study will recommend ways to mitigate the risk. Study will review the structural design criteria of the existing flues and ducts as compared to the negative potential of the new booster fan and the revised configuration.

The deliverable will be the write up of the study including any relevant data.

FD1780 Perform/Issue Process Cooling System Optimization Study

This study will verify the proposed cooling system assumptions from the Feasibility Study. If the assumptions are correct the study will optimize the cooling method and equipment location considering, but not limited to, the following:

- A stand alone cooling system
- Evaporative cooling
- Evaporative and air cooling
- A cooling system integrated into the existing AVS cooling system
- Adding an evaporative cooling water system to supplement the current AVS cooling system and then tapping into the current AVS cooling water
- A combination of cooling system integration with AVS and air cooling

If additional evaporative cooling is found to be optimum, the location of that cooling and the effects of its mist freezing onto surrounding structures in the winter will be studied for ways to avoid localized icing in vicinity of new cooling tower.

FD1790 Perform/Issue Storm Water and Sanitary Sewer Drainage Study

This study will determine if there is adequate capacity in the existing storm water and sanitary sewer drainage system at AVS needed for the new additional Powerspan process building. If not, this study will identify how these needs of the Powerspan process will be met.

The deliverable will be the write up of the study including any relevant data.

FD1792 Perform/Issue Potable Water Study

The feasibility study assumed that potable water could be provided from an existing AVS source. This study will identify this source and detail the associated cost to provide the water to the Powerspan process.

The deliverable will be the write up of the study including any relevant data.

FD1795 Perform/Issue Future Plant Upgrades Study

Considering any future upgrades, this study will verify that the Powerspan process island location and utility upgrades are designed with the appropriate future upgrade consideration.

The deliverable will be the write up of the study including any relevant data.

FD1800 Design Review of Optimization Studies

This review will occur upon completion of the optimization studies. All parties will discuss and agree upon the outcome of the studies, which sets the path for the more detailed design to proceed throughout the rest of the FEED study.

The deliverable will be action items from the meeting.

FD1800 Perform/Issue Interconnecting Piping Study

The deliverable will be the write up of the study including any relevant data.

FD1826 Design Review of Optimization Studies

This deliverable will be a milestone in the form of a meeting.

FD1835 Develop/Issue Plant Civil Site Plans (includes PI, BOP, ICP, compressor, etc.)

The BOP contractor will provide a detailed site plan based off FD1100.

Area investigation includes:

- Geo-tech and underground survey (FD1820)
- Pilot trenching
- Routing of piping & wiring including pipe-racks & cable trays

- General Arrangement Drawings - At the completion of this study, the placement of all major equipment should be finalized. The routing of major piping should be shown, but it might be considered incomplete since it may need to be slightly relocated due to interferences.

The deliverable will be copies of all drawings listed here.

FD1838 Develop/Issue Routing of Piping and Wiring Including Pipe Racks and Cable Trays

The deliverable will be routing and pipe rack General Arrangement drawings.

FD1850 Develop/Issue Civil/Structural/Architectural Design Basis

The contractors will provide a detailed plan. This design basis will cover conceptual aspects of this phase. Detailed specifications and drawings will follow after the FEED phase.

The deliverable will be a write up of the design basis.

FD1851 Perform/Issue Lightning Protection Study

The new Process Island structures and vessels will be evaluated to determine the type of protection required.

The deliverable will be the write up of the study including any relevant data.

FD 2048 Perform/Issue Condensate Monitoring Study

Steam condensate from the AVS steam cycle is routed through a process heat exchanger and then returned to the AVS steam cycle. Appropriate condensate conductivity monitoring

instrumentation and systems will be studied to avoid or minimize any contamination to the AVS cycle in the event that a leak from the process into the condensate occurs.

The deliverable will be the write up of the study including any relevant data.

FD2050 Develop/Issue Controls Design

The Powerspan control system must interact with the AVS control system and the Great Plains Synfuels Plant control system. It is paramount that the operations at AVS and the Great Plains Synfuels Plant are not disrupted by the Powerspan CO₂ capture process. However, reliable operation of the CO₂ capture facility is desired as well. The feasibility study assumed that a stand-alone control system would be used to serve the Powerspan process controls. This assumption must be verified and the theory of operation must be determined. To accomplish this, the following must be provided at a minimum:

- Cause and effect diagram
- Control system specifications
- Control system architecture diagram
- Preliminary control system quantities
- Control system narrative explanation
- I/O lists
- Instrument list
- Instrument data sheets
- Condensate monitoring controls (leak detection)
- CO₂ product gas monitoring system

The deliverable will be the write up of the study including any relevant data.

FD2067 Perform/Issue Preliminary HVAC Study

Design basis and conceptual information only will be provided for this phase.

The deliverable will be the write up of the study including any relevant data.

FD2068 Perform/Issue Preliminary Fire Protection Design

The following should be identified:

- Fireproofing design basis
- Fire protection sketches
- Preliminary fire protection system quantities

The fire protection system will comply with FM Global recommendations since this is Basin Electric's insurance provider.

The deliverable will be the write up of the study including any relevant data.

FD2096 Integrate all 3-D CADD Models

A 3-D model will be developed to match the level of engineering detail work completed during the FEED. The model will be refined during detailed engineering. All final engineering drawings shall be provided to the Owner in AutoCAD “.dwg” format. Electronic formatting other than AutoCAD will require approval from the Owner. Upon review of format, Owner will accept Microsoft Visio files and Microstation Version 8 files. Microstation Version 8 documents must use cells created with tags only, not data fields.

The deliverable will be the merged 3D model in CAD format.

FD2098 Develop/Issue - Safety Plan

A safety plan will be worked out per the arrangement assumed for ownership and operation of the proposed project. This safety plan will address:

- Management safety commitment
- Staffing plan for safety
- Safety education plan
- Evaluation and recognition safety plan
- Accident investigation plan
- Safety plan summary
- Process hazards analysis
- Hazardous area classification layouts

The deliverable will be the write up of the study including any relevant data.

FD2160 Develop/Issue Overall Capital Cost Estimate

The overall capital cost estimate accuracy is expected to be +/- 15% accurate. Including:

- Process Island (PI)
- Balance of Plant (BOP)
- Monte Carlo Analysis (To establish range of accuracy)

The deliverable will be the write up of the capital cost estimate and will be included in the overall cost estimate.

FD2230 Develop/Issue Overall Plant O&M Cost Estimate

The overall plant operating and maintenance cost estimate will be +/- 15% accurate.

The deliverable will be the write up of the O&M cost estimate and will be included in the overall cost estimate.

FD2300 Develop/Issue Overall Project Level 2 Schedule

This schedule will show the detailed engineering, procurement, construction, and start-up phases for the proposed project. It will also include:

- Discipline engineering execution plan
- Procurement execution plan
- Subcontract plan
- Labor survey
- Commissioning and completion execution plan
- Long lead item list

The deliverable will be the proposed schedule.

FD2350 Develop/Issue - Design frozen

The deliverable will be in the form of a milestone.

STANDARDS OF SUCCESS

The overall success of capturing carbon dioxide at AVS will be demonstrating that retrofitting and integrating the Powerspan ECO₂ technology into an existing power plant infrastructure is feasible. The commercial-scale demonstration at AVS will provide sufficient information to design, build and guarantee performance for full-scale ECO₂ systems in coal-based generation facilities across North Dakota and the United States. Coal provides 50 percent of the electricity generated in the United States and will continue to provide a significant portion of the generation portfolio for many years to come. The continuing climate change debate highlights the immediate need to demonstrate carbon capture from coal-based power plants if coal is to remain a viable and secure source of energy for our country.

The standards of success of the AVS project will be to complete a commercial sized demonstration of carbon capture that leads to commercialization of the technology. The project will capture 90 percent of the carbon dioxide in the slipstream and virtually eliminate remaining sulfur dioxide and particulate in this slipstream. The demonstration will provide an economic analysis and performance of Powerspan's ECO₂ technology that could provide a pathway for lignite's continued use in the future.

Another important goal of the AVS project is to coordinate the project with The Plains CO₂ Reduction (PCOR) Partnership managed by the Energy and Environmental Research Center (EERC) at the University of North Dakota. Basin Electric is a member of PCOR, one of seven Department of Energy (DOE) partnerships that are examining sequestration opportunities in their respective regions. In Phase III, PCOR will demonstrate a large volume sequestration test to demonstrate the safe, effective and permanent storage of carbon dioxide in different geologic formations, including Enhanced Oil Recovery. PCOR's other goals will include developing

industry standards for measuring, mitigation and verification, and addressing mineral and water rights and liability issues for CO₂ sequestration. The knowledge gained from PCOR and the other DOE regional partnerships will provide a basis for developing the legal and regulatory framework for widespread geological sequestration. Carbon capture and storage can proceed for Enhanced Oil Recovery under current North Dakota regulations. EOR will be a bridge to understanding sequestration in other geological formations.

BACKGROUND

Powerspan

Powerspan Corp., based in New Hampshire, has been engaged in the development and commercialization of innovative, proprietary emission control systems and technologies for coal-fired power plants for over 14 years. Founded in 1994 as Zero Emissions Technology Inc., and later renamed as Powerspan Corp., the company initially provided technology to control particulate emissions from coal-based electric power plants. As compliance deadlines of the Clean Air Act Acid Rain Program approached, Powerspan recognized the growing importance of a multi-pollutant solution for controlling emissions of sulfur dioxide (SO₂) and nitrogen oxides (NO_x) in addition to particulate emissions. Standard technology generally addresses each pollutant individually necessitating the installation of separate costly devices requiring large spaces not always available on space-constrained sites that are typical of existing power plants. Powerspan sought to develop an integrated approach to achieve multi-pollutant reductions at a lower cost than commercially available systems, enabling power plant owners to meet existing and future environmental requirements in a cost-effective manner. Powerspan's patented Electro-Catalytic Oxidation technology, or ECO[®], removes high levels of SO₂, NO_x, mercury, and fine particulate matter from coal-fired power plants. The ECO process also produces a valuable fertilizer co-product, ammonium sulfate fertilizer that minimizes landfill disposal of waste.

ECO[®] Development, Testing & Commercialization

Powerspan has successfully demonstrated the ECO multi-pollutant control process in a 50-megawatt (MW) commercial configuration at FirstEnergy's R.E. Burger Plant in Shadyside,

Ohio. The unit has met commercial performance objectives and demonstrated the capability to control outlet emissions to best available control technology standards or better. The ECO unit remains in operation at the Burger Plant.

The success of the 50MW ECO project has led to large scale, commercial projects. In June 2007, American Municipal Power-Ohio (AMP-Ohio) announced its commitment to install the ECO technology on its proposed 1,000 MW American Municipal Power Generating Station in southern Meigs County, Ohio. AMP-Ohio will use Powerspan's ECO technology as an SO₂, mercury, and particulate matter control option for its strong environmental performance and potential to add CO₂ capture. Full scale ECO projects are proceeding at other plants including a 640MW retrofit at an eastern power plant.

CO₂ Capture Research & Development

Powerspan has been developing a CO₂ capture technology, called "ECO₂[®]", for over four years. In May 2004, Powerspan and the U.S. Department of Energy (DOE) National Energy Technology Laboratory entered into a Cooperative Research and Development Agreement (CRADA) to develop a cost-effective post combustion CO₂ removal process for coal-based power. The regenerative process uses an ammonia-based solution to capture CO₂ in flue gas and prepare it for subsequent sequestration. After regeneration, the ammonia solution is recycled. In December 2007, Powerspan announced it had exclusively licensed a patent for the process from the DOE. The patent granted to the DOE represents the only patent issued in the U.S. to date covering a regenerative process for CO₂ capture with an ammonia-based solution.

In September 2005, FirstEnergy announced plans to pilot test the CO₂ capture process at the company's R.E. Burger Plant in Shadyside, Ohio, where the 50MW ECO unit is in operation. Powerspan is completing work on a one MW pilot scale unit that is designed to remove 90

percent of the CO₂ and capture approximately 20 tons of CO₂ per day. The pilot will be instrumental in evaluating the process performance under varying conditions and important for determining the economics for scale-up. The pilot plant is scheduled to be operational in October 2008.

QUALIFICATIONS

Powerspan Background and Experience

Powerspan has assembled a qualified project team for the AVS CO₂ capture demonstration project consisting of Powerspan and Burns & McDonnell. This team possesses the breadth of knowledge, discipline, and experience necessary to deliver this first of a kind commercial demonstration of the ECO₂ technology. The Project Team members and their primary roles are outlined below:

Powerspan- Technology Supplier, Project Lead

As the technology provider, Powerspan will assume a Project Management role for the FEED Study. Powerspan will oversee all aspects of engineering, schedule, budget, and reporting. Powerspan will also provide engineering services where required.

Burns & McDonnell- Balance of Plant Engineer

Powerspan has engaged the services of Burns & McDonnell as the balance of plant engineer for the project. Burns & McDonnell's extensive experience in evaluation and design of commercial systems coupled with their experience within the power industry will be essential to the success of the project.

Powerspan Project Experience

Powerspan is the only company in the U.S. that has demonstrated success in a program similar to that represented by Basin Electric's 120-MW CO₂ capture demonstration project. With the ECO multi-pollutant control process, Powerspan successfully demonstrated the capability of developing a major new pollution control technology and moving it from lab-scale and pilot-scale testing to full commercial-scale operation. Accordingly, Powerspan's experience in designing,

constructing, and operating the 50-megawatt ECO commercial demonstration unit at FirstEnergy's R.E. Burger Plant in Shadyside, Ohio, represents the Company's most relevant project experience. The success of this development effort is validated by American Municipal Power-Ohio's commitment to install the ECO-SO₂ technology on its proposed 1,000 MW American Municipal Power Generating Station in southern Meigs County, Ohio. (The ECO-SO₂ technology is the ECO process without the NO_x control component.)

Burns & McDonnell, participated in the FirstEnergy project. Through an EPRI-funded study, Burns & McDonnell conducted an independent engineering assessment of the ECO technology. Their reliability analysis for full-scale applications of the technology concluded that ECO is as reliable as conventional technology (> 99 percent available).

The organizational characteristics required to succeed in advancing technology from lab to pilot to commercial-scale are unique and difficult to duplicate. As utilities have experienced, there are substantial challenges in developing and scaling-up complex process technologies. When the challenges are not met or even recognized, the resulting installation falls far short of expectations. As demonstrated in developing their ECO technology, Powerspan has gathered a group of individuals and established a working culture that identifies and responds quickly and effectively to the challenges of adapting lab-based processes to the commercial demands of coal-fired power plants.

Combining this unique capability with the strengths of Burns & McDonnell creates a rare combination of talent, skills, and resources to meet the challenge offered by Basin Electric.

Significant Powerspan Milestones – ECO and ECO₂

Date	Milestone
October 1996	Developed the concept for ECO and filed our first patent application.
September 1997	Successfully demonstrated our ECO technology on a lab scale.
December 1997	Initiated a \$4.8 million ECO pilot test program at FirstEnergy's R.E. Burger Plant.
February 1999	Received our first ECO technology related patent.
May 1999	Achieved our first successful run on the ECO pilot unit at the Burger Plant.
December 2001	Received our first commercial order to install a 50 MW ECO system at FirstEnergy's Burger Plant.
July 2002	Announced alliance with Wheelabrator Air Pollution Control, Inc., (now part of Siemens Environmental Systems and Services, Inc.), to provide commercial ECO systems to the electric utility industry.
February 2004	Integrated system testing of the 50-MW ECO unit begins at the Burger Plant.
May 2004	Entered into a cooperative research and development agreement (CRADA) with the U.S. Department of Energy National Energy Technology Laboratory to develop a cost-effective CO ₂ removal process for coal-fired power plants. Scope of the agreement includes laboratory testing, pilot testing, and detailed studies of the CO ₂ capture process economics.

September 2005	Successfully completed 6-month performance run of the 50 MW ECO unit at the Burger Plant. FirstEnergy announced plans to pilot test our CO ₂ removal technology at the Burger Plant.
May 2006	FirstEnergy announced their Burger Plant was selected by the Midwest Regional Carbon Sequestration Partnership as a test site for CO ₂ sequestration. This announcement combined with the September 2005 CO ₂ pilot testing announcement offers a unique opportunity to both capture and sequester CO ₂ at the same plant.
June 2007	American Municipal Power-Ohio announced its commitment, approved by its Board of Trustees, to use the ECO technology on the proposed 1,000 MW AMP-Ohio Generating Station Project in southern Meigs County, Ohio. The AMP-Ohio Board of Trustees also approved a memorandum of understanding with Midwest Agribusiness. The Andersons, Inc., to handle processing and sale of the fertilizer co-product produced by the ECO process.
August 2007	Only patent issued to date on CO ₂ capture with ammonia is granted by the U.S. Patent and Trademark Office to the U.S. Department of Energy on August 14 – U.S. patent number 7,255,842. Under Powerspan's cooperative research and development agreement with the U.S. DOE National Energy Technology Laboratory, Powerspan retained the exclusive right to license this patent. Powerspan subsequently announced in December 2007 that it had exclusively licensed the patent from the DOE.

November 2007	NRG Energy, Inc., and Powerspan announced a memorandum of understanding for a one million ton per year CO ₂ capture and sequestration demonstration at NRG's WA Parish plant in Sugar Land, Texas. The demonstration is expected to be operational in 2012 with the captured CO ₂ expected to be used in enhanced oil recovery operations in the Houston area. The Parish plant burns coal from the Powder River Basin.
March 2008	Basin Electric Power Cooperative announced selection of Powerspan's CO ₂ capture technology for a Commercial Demonstration at their Antelope Valley Station. Selection of Powerspan's ECO ₂ technology was the result of the first competitive solicitation process for a CO ₂ capture demonstration at a coal-based power plant in the US. The proposed CO ₂ capture demonstration project will capture ~ 1 million tons of CO ₂ annually, which will be fed into an existing CO ₂ compression and pipeline system owned by Basin Electric's wholly owned subsidiary, Dakota Gasification Company.
June 2008	Basin Electric Power Cooperative announced the successful completion of the feasibility study for the ECO ₂ commercial demonstration at Antelope Valley Station.

As of August 2008, Powerspan employs 83 full-time employees. Of these employees, over half are engaged in research and development and engineering; 15 are full time Ohio-based employees; 6 are engaged in manufacturing and purchasing; 3 are engaged in sales and

marketing; and 12 are engaged in finance and administration. In addition, the company employs part-time consultants and contract employees in engineering, marketing, human resources, and finance.

Basin Electric Power Cooperative

Basin Electric is one of the largest electric generation and transmission (G&T) cooperatives in the United States. Basin Electric is a regional, consumer-owned, power supplier formed in 1961 to provide supplemental power to a consortium of electric distribution cooperatives. Basin Electric's core business is generating and delivering electricity to wholesale customers, primarily our member systems.

Basin Electric owns 2,499 megawatts (MW) and operates 3,412 MWs of electric generating capacity. Basin Electric supplies 126 rural electric member cooperative systems with wholesale electric power who distribute the electricity to 2.6 million consumers.

Basin Electric owns 1,791 miles of high voltage transmission lines and 56 substations. Basin Electric owns 76 microwave/fiber optic installations used for communications and system protection. Our service territory spans about 430,000 square miles in the central United States from the Canadian border to Mexico, including parts of North Dakota, South Dakota, Montana, Wyoming, Minnesota, Nebraska, Iowa, Colorado and New Mexico.

Basin Electric, the parent company to seven subsidiaries, has base-load generation facilities in the western North Dakota lignite coal fields and the Wyoming Powder River Basin (PRB) coal reserves. Basin Electric also owns and operates peaking, distributed, and renewable generation facilities in four states. Corporate headquarters are in Bismarck, North Dakota. Basin Electric and its subsidiaries employ more than 1,900 people.

Basin Electric's subsidiary: Dakota Gasification Company (DGC)

Basin Electric has extensive institutional knowledge of coal gasification, carbon capture, and CO₂ sequestration through its subsidiary, Dakota Gasification Company (DGC).

DGC owns and operates the Great Plains Synfuels Plant, the only commercial-scale coal gasification plant in the United States that manufactures synthetic natural gas. The Great Plains Synfuels Plant genesis lies in the energy crisis of the 1970's when Americans felt the tightening grip from oil-producing nations of the Middle East. It is the only project operating today that is tied to the Federal Non-nuclear Energy Research and Development Act of 1974, which was enacted to spur developments that could help the United States achieve energy independence.

The \$2.1 billion plant began operating in 1984. Using the Lurgi gasification process, the synfuels plant gasifies lignite coal to produce valuable gases and liquids. The average daily production is 160 million standard cubic feet of synthetic natural gas (SNG), the majority of which is piped to Ventura, IA, for distribution in the eastern United States. Many byproducts and alternate products are produced and marketed in the United States and worldwide. The Synfuels plant daily consumes about 18,500 tons of lignite supplied by the nearby Freedom Mine.

The Great Plains Synfuels Plants is environmentally unique with the ability to capture CO₂ as a byproduct. In 2000, DGC constructed a 205-mile pipeline to Weyburn, Saskatchewan, for enhanced oil recovery. The CO₂ is expected to be permanently sequestered in the oil reservoir and is being monitored by the International Energy Agency (IEA) Weyburn CO₂ Monitoring and Storage Project.

Dakota Gasification's Synfuels Plant began selling carbon dioxide to oil producers in Saskatchewan, Canada in 2000. The carbon dioxide is recovered by a Rectisol process that captures carbon dioxide with a purity of about 95 percent. The carbon dioxide is compressed using three identical MAN Turbo AG compressors in parallel. These eight-stage, 19,500 hp compressors increase the carbon dioxide pressure from about 7 pounds per square inch guage (psig) to nearly 2,700 pounds psig. Each compressor has a flow capability of 57 million standard cubic feet per day (mmscf/d). Currently, the Synfuels Plant captures approximately 49 percent of the carbon dioxide previously emitted to the atmosphere.

CO₂ Pipeline

Following compression, the carbon dioxide enters a 205-mile pipeline. From the Synfuels Plant to Tioga, ND the pipe is 14 inches in diameter. A booster pump is located near Tioga, ND, to increase the product's flow rate and maintain desired pressure at the delivery points in Canada. The pipeline segment from Tioga, ND, to the delivery point is 12 inches in diameter. Design flow rate for the booster pump is 154 mmscf/d.

The pipeline has a design capacity of 240 mmscf/d. The pipeline passes through the heart of North Dakota's oil country and is nearby significant oil fields in Montana. Eleven tap points were installed on the pipeline during construction. These taps allow take off of carbon dioxide from the pipeline for another customer without forcing a shutdown of the pipeline. The first tap is located near Killdeer, ND, and the last tap is located in Saskatchewan. The other taps are interspersed from the Little Missouri River to the North Dakota/Canada border.

CO₂ Marketing

Through 2006, Dakota Gasification has successfully marketed over 13 million tons of carbon dioxide to two Canadian customers. EnCana Oil & Gas Partnership (formerly PanCanadian

Resources) utilizes the Synfuels Plant's carbon dioxide for EOR in its Weyburn Field. The other customer, Apache Canada, Ltd., uses the carbon dioxide for EOR in its Midale field. Total carbon dioxide demand is 152.7 mmscf/d.

With a pipeline design capacity of 240 mmscf/d and aggregate demand of 152.7 mmscf/d, the pipeline could certainly handle additional volumes of carbon dioxide. The addition of an identical carbon dioxide compressor at the Great Plains Synfuels Plant would allow another 57 mmscf/d of carbon dioxide to be transported. If a new customer would be located upstream of Tioga, ND, this volume could be delivered without the addition of another booster pump. If the new customer is located downstream of Tioga, ND, it is likely that a booster pump would be needed.

Antelope Valley Station

The source for the additional carbon dioxide would be the Antelope Valley Station. The station consists of two pulverized lignite-fired electrical generation units, each capable of producing 450 MW. The plant consumes about 17,000 tons per day of lignite. Currently, Antelope Valley uses dry scrubbers and baghouses for sulfur dioxide and particulate removal before flue gases enter the stacks. Flue gas could be taken downstream of the scrubbers and baghouses and transported to a carbon dioxide capture system. The capture system would be designed to capture approximately 57 mmscf/d of carbon dioxide. The captured carbon dioxide would then be delivered by pipeline to the compressor station at the Synfuels Plant and injected into the 205-mile pipeline. The close proximity of Antelope Valley to the Synfuels Plant provides the advantage of needing only roughly 5,000 feet of pipe to deliver the carbon dioxide from Antelope Valley to the compressor station.

Strategic Fit

With a carbon dioxide capture technology for pulverized coal power plants becoming commercially available, this equipment can be installed at Antelope Valley Station and the carbon dioxide can be delivered to the pipeline for expanded carbon dioxide sales. The challenge is to determine what technology or technologies will work at Antelope Valley and at what cost. The Energy and Environmental Research Center (EERC) in its Plains CO₂ Reduction Partnership (PCOR) would also be a strategic partner with its Phase III program. PCOR Phase III objectives are to develop a project that leads to commercial success while satisfying the Department of Energy (DOE) goals and objectives.

Plains CO₂ Reduction Partnership (PCOR)

The EERC has been the leading agency in PCOR since its inception in December 2003. Basin Electric and Dakota Gasification Company have participated in PCOR since its beginning. PCOR has completed the first two phases of its study and is preparing an application for Phase III. Phase III would implement large volume sequestration tests to demonstrate the safe, effective, and permanent storage of carbon dioxide in different geologic formations in North America that could offset 50 percent of the current levels of carbon dioxide emissions in each region for the next 100 years. The EERC Phase III goals are the following:

- Meet or exceed our partner's expectations – develop a project that leads to commercial success.
- Develop infrastructure and expertise that gives our region a competitive advantage in the future.
- Develop public support through outreach and education.
- Develop standards for Mitigation, Monitoring and Verification (MM&V).

- Develop markets and standards for the monetization of carbon credits.
- Develop user-friendly standards for:
 - Site selection/permitting
 - Risk management

With the additional carbon dioxide capacity and the pipeline passing through the Williston Basin oilfields, this project would lend itself well for use and recognition for the PCOR – Phase III – Demonstration Project. Basin Electric would work closely with the EERC in Grand Forks, ND, to include this project in PCOR - Phase III.

VALUE TO NORTH DAKOTA

The successful demonstration of carbon capture technology at Antelope Valley Station will benefit North Dakota lignite by providing a path for retro-refitting existing lignite power plants and building new lignite power plants with carbon capture technology. In the event of carbon restraints either through legislation or regulation, existing and new lignite-based power generation plants will have the proven commercialized technology to capture the carbon dioxide emissions to be in compliance. The permitting and building of new coal-based electrical plants in a carbon constrained world will hinge on the ability to capture the carbon dioxide emissions. North Dakota has excellent carbon dioxide storage capacity in both enhanced oil recovery and saline aquifer application. Using the carbon dioxide for enhanced oil recovery would be the first choice as it would provide economic value for the carbon dioxide and benefit the state through increased oil production.

While it is the 'king' of electrical power generation, coal has come under increasing scrutiny from environmental and political interest groups. Over the past several decades the pressure has focused on SO_x and NO_x, particulate matter and mercury emissions. Lately, the concerns about global warming have caused carbon dioxide emissions to become a major issue. It now appears that most Americans perceive global warming to be a threat and Congress is responding to that perception. Basin Electric believes that some form of carbon dioxide management or carbon dioxide constraint will be necessary to continue and/or increase its use of coal for power generation.

On July 11, 2008, the Environmental Protection Agency (EPA) issued an Advanced Notice of Proposed Rulemaking: Regulatory Greenhouse Gas Emission under the Clean Air Act. This was in response to the United States Supreme Court's April 2007 decision in *Massachusetts vs.*

EPA. In that landmark opinion, the Supreme Court held that carbon dioxide and other greenhouse gases are “pollutants” under the Clean Air Act. The fact that greenhouse gases are considered pollutants will trigger a requirement for EPA to make an “endangerment” finding. The finding would determine as to whether greenhouse gases endanger public health or welfare. An endangerment finding, once made, would require EPA to begin rulemaking to bring greenhouse gases within the scope of the Clean Air Act.

With North Dakota’s generation portfolio heavily coal-based, the enforcement of CO₂ legislation or EPA regulation poses a risk to the future of existing coal based generating resources and the building of new coal-based generation resources. Demonstrating carbon capture technology that will lead to commercialization could help mitigate potential harmful effects of new legislation or regulation.

MANAGEMENT

Basin Electric

James J. Sheldon will serve as the project coordinator keeping all facets of the project moving forward toward a successful completion. Mr. Sheldon is a registered Engineer-In-Training in the State of North Dakota with over three years of electric utility experience. He will lead the development of the CO₂ capture demonstration project.

Mike Paul will provide oversight of the Antelope Valley Station CO₂ capture demonstration project. Mr. Paul is a registered Professional Engineer in the State of North Dakota with over 25 years of electric utility experience. Mr. Paul's supervision will provide advisement and direction to all aspects of the project.

Additionally, Fred Stern will provide technical support for the project. Mr. Stern has over 30 years of coal-based power generation and coal gasification experience. Mr. Stern was the plant manager of the Great Plains Synfuels Plant when the decision was made to begin capturing and marketing the CO₂ at the plant. Mr. Stern has extensive knowledge of carbon dioxide capture, the transport and the end use in enhanced oil recovery.

Powerspan Key Personnel

Francis R. Alix, Chairman, Chief Executive Officer

Frank Alix co-founded Powerspan in 1994. Frank has over 25 years of experience in energy related fields. Prior to assuming his present role at Powerspan, Frank worked as a venture capital investor where he directed investments in early-stage technology ventures. Frank has over 15 years' experience in the construction, maintenance, and repair of nuclear power plants on submarines. He began his career at General Dynamics and later worked as a senior nuclear

engineering manager for over nine years at Portsmouth Naval Shipyard. There, Frank headed the Nuclear Test Engineering and Mechanical Engineering Divisions where he was responsible for more than 200 engineers and technicians. As the head of the NR-1 Engineering Group, Frank was responsible for all electrical and mechanical propulsion plant systems during the first Submarine NR-1 Refueling overhaul. Frank has a B.S. in Nuclear Engineering from the University of Massachusetts-Lowell and an M.B.A. from the University of New Hampshire. Frank is co-inventor on several of Powerspan's patents.

Phillip D. Boyle, President and Chief Operating Officer

Phil Boyle joined the company as Vice President of Engineering in 1996 after spending 20 years with the Naval Nuclear Propulsion Program. In his role as Program Manager for Shipyard Matters, Phil was responsible for oversight and direction of nuclear work at four public and two private shipyards. Prior to this, Phil served as the Naval Reactors Representative for eight years at the Portsmouth Naval Shipyard, overseeing maintenance and refueling of nuclear submarines. Earlier in his career, Phil led the headquarters design group for reactor plant fluid systems for the Navy's Fleet Ballistic Missile submarine, the TRIDENT Class. Phil holds a B.S. in Engineering Physics and a Master's of Engineering, Nuclear Engineering, both attained at Cornell University. Phil also holds an M.B.A. from the University of New Hampshire.

David Bernier, Vice President, Projects

Dave Bernier came to Powerspan in 2000 from Hatch Technology Group, an engineering consulting firm that he co-founded. As President, Dave was responsible for strategic planning, business development, design/R&D coordination, marketing, and project management. In his previous position, he was Plant Operations Manager for Molten Metal Technology's Research and Development facility, where he managed the design, construction and start-up of a "first-of-a-kind" hazardous waste processing plant. He served for nine years at the Portsmouth Naval

Shipyard as a production engineer, project leader, and production engineering manager for the naval nuclear submarine refueling overhaul. Dave earned his B.S. degree in Mechanical/Nuclear Engineering from Worcester Polytechnic Institute, and holds an M.B.A. from the University of New Hampshire.

TIMETABLE

The start of the FEED study for the AVS CO₂ capture demonstration project will begin after one month of successful operation data is available from Powerspan's pilot plant at the Burger Station. Basin Electric anticipates the start of the six-month FEED study in December 2008 and completion in May 2009. The current schedule of the AVS CO₂ capture demonstration project is provided in Appendix C. Interim reports will be submitted as required and a final report will be submitted upon completion of the FEED study.

BUDGET

Powerspan FEED Study Estimate	\$ 5,000,000
Administration and Internal Costs Estimate	\$ 400,000
	<hr/>
	<hr/>
	\$ 5,400,000

Basin Electric is seeking support for the contracted Powerspan's FEED study portion of the budget and the associated cost to administer and support the FEED engineering and design. The administrative and internal costs associated include staff time, travel and additional outside contract work to support the FEED study. The FEED study is necessary to provide sufficient information for a final determination to proceed with the project. There is always risk in being the first to commercialize a new advanced clean coal technology; however, it is imperative to the lignite industry that carbon capture technology is given a complete and thorough analysis. The North Dakota Lignite Research Development partnership is vital to utilities willing to risk building the first of a kind and developing new technology that would have a wide application to all utilities in North Dakota and the United States.

MATCHING FUNDS

Total project value is \$5,400,000. Basin Electric Power Cooperative requests \$2,700,000 from the North Dakota Industrial Commission Lignite Research & Development Program for approximately half the cost of the Powerspan FEED study. Basin Electric will provide the industry matching cash and in-kind cost share of \$2,700,000 with written commitments following funding approval by the Industrial Commission. Matching funds commitment is subject to Board of Directors' approval.

TAX LIABILITY

I, Clifton T. Hudgins, certify that Basin Electric Power Cooperative does not have any outstanding tax liability owed to the State of North Dakota or any of its political subdivisions.

Clifton T. Hudgins

Senior Vice President

Chief Financial Official

Date

CONFIDENTIAL INFORMATION

All non-confidential data as determined by Powerspan will be placed in the public domain as part of the Antelope Valley Station CO₂ capture demonstration project. The final report summarizing the project and its findings will be public information; however, intellectual property on Powerspan's process will remain as confidential information.

APPENDIX A

Resumes of key personnel

James J. Sheldon, EIT

Basin Electric Power Cooperative

1717 East Interstate Avenue

Bismarck, ND 58504-0561

(701) 355-5762

james@bepc.com

Qualifications

- B.S., Mechanical Engineering, North Dakota State University
- Registered Engineer in Training, North Dakota
- Over 3 years of electrical utility experience with one year at two different coal-based power plants

Professional Experience

June 2006 to present

Basin Electric Power Cooperative, Headquarters Office, Bismarck, ND

Mechanical Engineer

- Project Coordinator for the Antelope Valley Station CO₂ capture demonstration project.
- Project Engineer during early stages of roughly 200 MW of wind power generation development.

- Supported studies for ethanol co-generation combined heat and power plants in North Dakota and Iowa.
- Assisted in numerous projects to support Basin Electric Power Cooperative's coal-fired power plants as well as their members and subsidiaries.

March 2006 to June 2006

Basin Electric Power Cooperative, Leland Olds Station, Stanton, ND

Mechanical Engineer (*first year headquarters training*)

- Coordinated the installation of 46 long retractable sootblowers and the relocation of all sootblower piping on the upper half of the boiler building during a major maintenance outage.
- Expanded knowledge of all power plant systems during inspection of several pieces of equipment and systems.

May 2005 to March 2006

Basin Electric Power Cooperative, Antelope Valley Station, Beulah, ND

Mechanical Engineer (*first year headquarters training*)

- Assisted in the data gathering and evaluation of an Optimized Plant Retrofit study.
- Developed a strong power plant operation and maintenance understanding through problem solving of day-to-day maintenance problems and performance concerns.

Professional Memberships, Certifications, Organizations

- Registered Engineer in Training in the state of North Dakota
- American Society of Mechanical Engineers

Frederick R. Stern

Accomplishments

- Sixteen years of experience as a Plant Manager within the Basin Electric Power Cooperative and Dakota Gasification Company organizations. The most current experience being the Plant Manager of Dakota Gasification's Great Plains Synfuels Plant for nearly eight years. During my thirty years with BEPC, twenty-seven of those years have been in supervisory or management positions.
- In my opinion, my accomplishments in the early years were due to project and start-up successes based on technical knowledge, common sense approaches, hard work and long hours.
- In the following years, my accomplishments were based on these same attributes, recognized organizational skills and care for those personnel assigned to my position.

Professional Experience

- **Executive Business/Technology Advisor** (part time) – BEPC/DGC, 2007 to present
- Pursue, study and review potential opportunities for plant expansion or enhancement and opportunities for additional CO₂ capture and sales.

Plant Manager - DGC, Great Plains Synfuels Plant, Beulah, ND 1999 - 2007

- Oversaw all operations, maintenance and engineering functions.
- During my tenure, a five-year plan has been implemented for the complete change out of the plant's process control systems. A system to gather, transport and sell carbon dioxide has been put into service. A Wet Electrostatic Precipitator was placed in service,

bringing DGC into environmental compliance for the first time in its history. The plant's personnel performed admirably during the first ever planned 'Black Plant' maintenance turnaround, during adverse conditions, and in recovering from a fire in December 2004.

Plant Manager – BEPC, Leland Olds Station, Stanton, ND 1991 – 1999

- Oversaw and coordinated all operations, maintenance and engineering functions.
- During my tenure the Unit 1 Control System was replaced, a new ash handling system was constructed and a new coal unloading station for rail cars was installed.

Maintenance Superintendent – BEPC, Antelope Valley Station, Beulah, ND 1985 - 1991

- Oversaw all plant maintenance including plant and contractor personnel.
- Established the first use of maintenance planners at a BEPC facility.

Plant Engineer – BEPC, Antelope Valley Station, Beulah, ND 1982 - 1985

- Hired, organized and supervised the plant's initial engineering group. Oversaw all project engineering and performance testing.
- Worked start-up of both AVS units.

Staff Chemical Engineer, Results Engineer and Plant Engineer – BEPC, Laramie River Station, Wheatland, WY 1979 - 1982

- Initial assignment was start-up of BEPC's first FGD scrubbers. Later, I was assigned the additional functions of supervising all laboratory personnel and finally supervision of all plant engineering.
- Worked start-up of all three LRS units.

Staff Chemical Engineer – BEPC, Leland Olds Station, Stanton, ND 1978 - 1979

- Completed various engineering projects including the first injection of limestone as a fireside ash conditioning additive. Also, worked plant maintenance outages.

Education

Master of Science in Chemical Engineering with Management Minor - University of North Dakota, Grand Forks, ND - 1978

Bachelor of Arts in Chemistry with Math Minor - Dickinson State University, Dickinson, ND – 1975.

Community Involvement

Knife River Care Center – Chairman of Governing Board

Zion Lutheran Church – Past Vice Chairman of Church Council and Past Chairman of Stewardship and Finance Committee.

Sakakawea Medical Center Foundation – Director

Mercer County Economic Development Committee – Director

Lakeshore Estates Homeowners' Association – Board Member and Treasurer for 13 years.

Currently, serve as Secretary and Current Certified Water Operator

First Security Bank-West – Director

MICHAEL W. PAUL, P.E.
Basin Electric Power Cooperative
1717 East Interstate Avenue
Bismarck, ND 58503-0564
(701) 355-5691
mikepaul@bepc.com

Qualifications

- B.S., Mechanical Engineering, University of North Dakota
- Registered Professional Engineer, North Dakota
- Over 30 years of electrical utility experience with six years stationed at three coal-based power plants

Professional Experience

December 2005 to present

Basin Electric Power Cooperative, Headquarters Office, Bismarck, ND

Vice President, Engineering & Construction

Provide central engineering and construction support services to meet the needs of Basin Electric. The Engineering & Construction Division is responsible for providing a broad range of strategic planning, research, design engineering, project management, construction management for Basin Electric, including new and existing operating facilities.

May 2001 to December 2005**Basin Electric Power Cooperative, Headquarters Office, Bismarck, ND****Manager, Mechanical and Performance Engineering**

Manage the Mechanical and Performance Section of the Generation Department, Engineering and Construction Division to provide professional engineering support for Basin Electric's existing operating facilities, members, and subsidiaries. Also conduct studies and planning for future generation resources as well as options for meeting future needs at existing facilities. Served as Project Coordinator for the Wyoming Distributed Generation Project and currently assigned as Project Coordinator for the Leland Olds Station Repowering Project Study.

March 1987 to May 2001**Basin Electric Power Cooperative, Headquarters Office, Bismarck, ND****Mechanical/Performance Engineering Supervisor**

Supervised the Mechanical/Performance Section of the Operations & Engineering Department, Engineering Division to provide professional, cost-effective and timely mechanical design and performance engineering activities for each of our coal-fired plants, as well as for our members and subsidiaries. Activities focused on coal-based power plant operations, performance, and maintenance activities to help ensure safe, reliable, and efficient operation. Assigned as Project Engineer for the Wyoming Distributed Generation project and was actively involved in the future coal-based generation and Leland Olds Station future options studies.

January 1986 to March 1987**Minnkota Power Cooperative, Milton R. Young Station, Center, ND**

Engineering Superintendent

Managed the overall generation engineering needs of Minnkota including supervision of professional staff and employees represented by a bargaining agreement. Established and directed the overall plant performance program, coordinated design changes and procurement of equipment and systems, monitored plant water management and chemistry programs, conducted economic and technical feasibility studies, provided technical support and recommendations on plant operations, prepared budgets, and directed plant documentation and drafting efforts. Responsibilities also included working with Minnkota headquarters departments and the other Square Butte project participant.

August 1983 to January 1986

Basin Electric Power Cooperative, Antelope Valley Station, Beulah, ND

Results Engineer

Monitored and reported performance of plant equipment and systems, ensured proper chemistry control of all plant systems, directed plant water management including environmental concerns, supervised lab technicians, assisted in design and operational modifications of plant equipment and systems, and monitored coal quality.

September 1982 to August 1983

Basin Electric Power Cooperative, Antelope Valley Station, Beulah, ND

Mechanical Engineer

Involved with initial Unit 1 start-up, including design changes, supervised boil-out and boiler chemical cleaning, prepared and supervised equipment testing for a full American Society of Mechanical Engineers turbine test, participated in water balance and vibration monitoring, and provided technical support to plant operations and maintenance.

Worked closely with design, construction, and start-up groups.

October 1979 to September 1982

Basin Electric Power Cooperative, Production/Design Division, Bismarck, ND

Mechanical Design Engineer

Monitored and directed the design and purchase of mechanical equipment and systems for the Antelope Valley and Laramie River Stations.

May 1978 to October 1979

Basin Electric Power Cooperative, Wm. J. Neal Station, Velva, ND

Mechanical Engineer

Engineering and supervision of a plant upgrade to 50 MW, compliance testing of retrofit precipitators, monitored progress of a Babcock & Wilcox pilot dry scrubber, engineering and initial test burns of sunflower hulls in the main boilers, and operating plant engineering and supervision as required.

September 1977 to May 1978

Engineering Experiment Station, University of North Dakota, Grand Forks, ND

Student Engineer

Involved in the engineering of several solar energy and heat pump projects.

June 1977 to August 1977

Clark Equipment Company, Melroe Division, Gwinner, ND

Summer Engineer

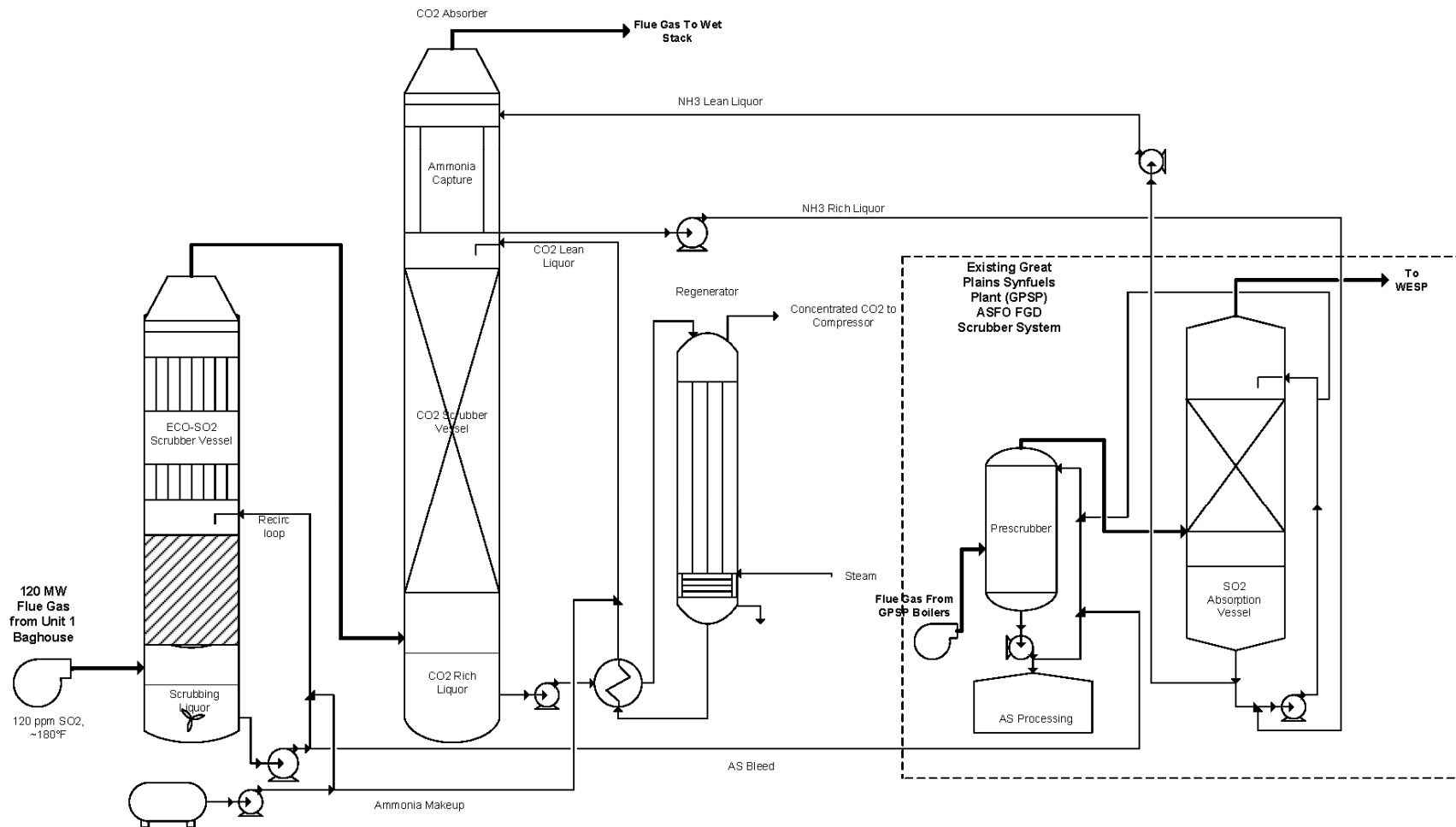
Quality control for welding, fabricating, machining, and assembling various models of the Bobcat skid steer loader.

Professional Memberships, Certifications, Organizations

- American Society of Mechanical Engineers
- Registered Professional Engineer in the State of North Dakota
- North Dakota State Department of Health, Certification as a Class II Water Treatment Plant Operator
- Energy Generation Conference Executive Committee – five years

APPENDIX B

Proposed 120MW ECO2 System Configuration Antelope Valley Station



AVS Milestone Schedule

